

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Workshop Materials: Physics Teaching and the
Development of Reasoning

ADAPT Program -- Accent on Developing
Abstract Processes of Thought

1975

Module 10: Teaching Goals and Strategies

Francis P. Collea

California State University, Fullerton

Robert Fuller

rfuller@neb.rr.com

Robert Karplus

University of California, Berkeley

Lester G. Paldy

SUNY, Stony Brook

John W. Renner

University of Oklahoma

Follow this and additional works at: <https://digitalcommons.unl.edu/karplusworkshop>

 Part of the [Science and Mathematics Education Commons](#)

Collea, Francis P.; Fuller, Robert; Karplus, Robert; Paldy, Lester G.; and Renner, John W., "Module 10: Teaching Goals and Strategies" (1975). *Workshop Materials: Physics Teaching and the Development of Reasoning*. 11.

<https://digitalcommons.unl.edu/karplusworkshop/11>

This Article is brought to you for free and open access by the ADAPT Program -- Accent on Developing Abstract Processes of Thought at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Workshop Materials: Physics Teaching and the Development of Reasoning by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

Module 10 Teaching Goals and Strategies

Introduction

Most physics classes include students who use concrete reasoning patterns on some occasions, formal reasoning patterns on others. Most likely their approach to a new kind of problem will include a mixture of techniques derived from their previous learning, their awareness of their own reasoning, and their ability to engage in self-regulation. Obstacles to their success may stem from misconceptions they formed as a result of poorly assimilated prior learning experiences. So what? What does that tell me about the goals and strategies I might choose for my teaching? In this module we shall pursue the implications of the students' needs to begin learning by using their existing mental structures, but to form new ones through self-regulation as part of their progress. Since this module outlines the last workshop activities, we invite you to bring up during the discussion any related matters about which you have questions.

Objectives

To assist you in selecting teaching strategies that will encourage self-regulation on the part of your students.

To assist you in balancing course goals aimed at content with those aimed at improved reasoning.

Procedure

Please find a partner with whom you can discuss some of the points raised while you read the two essays in the attached instructional materials. After you complete the reading, join a discussion group to compare your ideas concerning course goals and teaching strategies with those of other participants and workshop staff. For your reference, we have included a brief recapitulation of the major ideas proposed in the workshop.

Module 10 Instructional Materials

1. Essay. Teaching Strategies for Self-Regulation

How can you emphasize learning and progress in reasoning through self-regulation for your students? Though we cannot offer a widely-tested prescription, we can describe some steps we have found useful.

1. Plan your teaching to start with more concrete (operational) definitions of the important concepts and gradually introduce more formal meanings. Introduce new concepts and definitions with the help of concrete examples, demonstrations, and experiences for your students. Forces, for instance, can be illustrated with springs, bow-and-arrow, magnets, friction, and plumb lines. Waves can be illustrated by a ripple tank, a slinky, and a long elastic rope. A Cartesian coordinate system can be represented by three dowels tied together and marked X, Y, Z. A balloon can be used to represent a Gaussian surface, a pencil the normal vector, and a pen the electric field.
2. Regardless of the text you use, become aware of its strengths and weaknesses by reading it carefully to identify the demands for reasoning it places on its readers. We have often been amazed when we did that!
3. Use the learning cycle to organize laboratory activities and discussion sessions by always beginning with a task the students can define and organize partially for themselves. (Asking, "Do you have any questions?" is not such a task, but describing a simple physical situation and challenging students to pose a problem derived from it is one.)
4. Supplement the text by remarks in the lectures or in study guides that will especially help students with concrete mental structures.
5. Propose unlikely observations, unsatisfactory hypotheses, or incorrect conclusions "tongue-in-cheek" and challenge your students to evaluate these. A good example is the "capillary sprinkler": after students learn to compute the capillary rise of water in a tube, describe a tube that is too short for the rise derived from its diameter -- what will happen to the water at the top?
6. Encourage students to interact with one another during discussions, laboratories, or problem-solving sessions. Students can learn a great deal from one another during group efforts at school or at home, supervised or unsupervised. Students using formal reasoning patterns serve as role models for the more concrete thinkers, while the latter will challenge, through their questions and difficulties, the explanations and ideas provided by the text or their more advanced colleagues' short-cuts in reasoning.
7. Allow students who have made a mistake to present their complete incorrect procedure for analysis by their classmates. Change the emphasis of your teaching from the "right answer" to an understanding of the method.

8. In conversation during discussions, office hours, or tutorial sessions call your students' attention to their own reasoning. You might ask them to explain or justify their conclusions, predictions, and inferences regardless of whether these are correct or incorrect. "Are you sure of that?" "What is the evidence?" "Could you explain that to me?" "Is there another way of thinking about that problem?" are questions that might be asked of a group or of an individual student.
9. When you select problems for an assignment or test, keep in mind that a problem makes demands on physics knowledge and on mental structures. Use "I.Q. Test" type of problems, in which complicated and ingenious reasoning overshadows the physics, only as supplementary material for the more advanced students.
10. Assign specially constructed problems that encourage students to evaluate their own reasoning as described in Module 8. Encourage students to come to office hours or tutorial sessions for a review of their work on these problems so they may receive individual assistance that can help initiate self-regulation. If necessary, reduce the staff assigned to discussion sections, which rarely meet this need.
11. Use your students' performance on their physics activities to assess their reasoning patterns with respect to physics. While the tasks presented in the first few modules of this workshop have been designed for standardized interpretation of the results, we do not recommend their use to you unless you are interested in conducting research in this field and wish to compare your observations with those made at other institutions. If that is the case, please consult some of the references in Module 11 for a description of research studies. If that is not the case, you will get sufficient insight into your students' mental structures by listening carefully as they respond to their physics problems or ask questions in your lectures. Please keep in mind that you are concerned less with whether their answers are right or wrong, and more with their procedures for finding it.

In addition to these specific approaches we urge you to become more aware of your own interaction with your students. Do you tell them all the "answers" and expect them to give these back to you on a test? (Not recommended) Do you reveal that you are sometimes unsure of how to proceed but use certain techniques for identifying and evaluating alternatives? (Recommended) Do you try to recognize the misconceptions that may block their understanding (e.g. treating energy as vector, not distinguishing the integrals over electric field in Gauss's law and the definition of potential)? (Recommended)

Discuss a few items on the above list with your partner and then list below some teaching techniques that you have used to further the reasoning patterns of your students.

2. Essay. Course Goals: Content or Reasoning

It would be much easier to teach students who already apply formal reasoning patterns in their physics studies than to teach students who need to experience self-regulation first. And yet, the instructor who intends to cover new material must expect to allow for self-regulation if he wishes the students to come to a good working understanding of the new ideas. How much time will be needed depends on the level of the course and preparation of the students. Less time will be needed in an advanced course whose students have formed some of the formal mental structures previously. More time will be needed in an introductory course whose students are less experienced and may include a small number with no formal mental structures at all.

In view of these considerations, we should like to rephrase the question in the title of this essay to "Course Goals: Content With or Without Reasoning?" The reasoning patterns are closely related to the subject matter you select. Usually physics teachers have defined course goals exclusively according to the major topics covered, with a great deal of freedom for the individual instructor as regards emphasis and elaboration of details. Now you have to consider including goals related to your students' reasoning. Are these compatible with all the content goals? Are the topics in your course sequenced in order of increasing use of formal mental structures? Is there sufficient opportunity for concrete experience in the laboratory? Are there provisions for making students aware of their own reasoning so that they can initiate self-regulation?

3. Discussion

Please join with a group of participants and workshop staff to discuss some of the following questions. On the next page we have a recapitulation of the major points presented in this workshop for your quick reference.

1. Have you any indications of concrete reasoning patterns used by students in your courses? Describe some of your observations.
2. Do you feel a need to make the development of reasoning, as described in this workshop, an important course goal to which you will subordinate some other goals? If so, what kinds of changes will you make? How could you tell your students about this goal?
3. What possibilities are there within your courses for helping your students build formal mental structures?
4. What contributions can the traditional physics lectures make to self-regulation and the building of formal mental structures?
5. What contributions can the physics laboratory in your course make to self-regulation and the building of formal mental structures?
6. What contributions can discussion sections or office hours in your course make to self-regulation and the building of formal mental structures?
7. How might new course formats, such as Keller plan or Audio-Tutorial be particularly appropriate for stimulating self-regulation and building formal mental structures?

4. Recapitulation of Major Ideas

1. Piaget's theory describes two stages of logical reasoning in human intellectual development, the stage of concrete thought and the stage of formal thought. Earlier stages identifiable in the behavior of very young children may be called pre-logical.
2. Each of the two stages is characterized by certain reasoning patterns that reflect the mental structures used by the individual to classify observations, interpret data, draw conclusions, and make predictions.
3. The two stages are idealizations, in that most persons after age twelve use formal reasoning patterns under some conditions and concrete reasoning patterns under others. The latter is likely to occur whenever the subject matter is unfamiliar, as is the case for a student beginning work in a new academic discipline. The former is likely to be the case for an experienced worker in the academic discipline.
4. The process whereby an individual advances from the use of concrete reasoning patterns in an area of knowledge to the use of formal reasoning patterns is called self-regulation. Self-regulation begins with one's awareness that the concrete reasoning patterns are inadequate and proceeds through direct experience with the phenomena supplemented by the introduction of the related organizing principles and major concepts.
5. A person who has only concrete mental structures is likely to proceed through self-regulation in a new subject much more slowly than a person who has developed some formal mental structures in connection with other studies. The latter person benefits from the possibility of transferring the formal mental structures to the new area, especially if the new and old are closely related as is the case with mathematics and certain topics in physics.
6. Some students who are required to learn formal-level material in a subject in which they have so far developed only concrete mental structures -- or possibly no mental structures at all -- may draw on their own experience in related areas and their awareness of their own learning problems to go through self-regulation spontaneously. Other students, with less experience or self-awareness, are not likely to experience self-regulation; instead, they will memorize certain prominent formulas and procedures, but will apply these unreliably.